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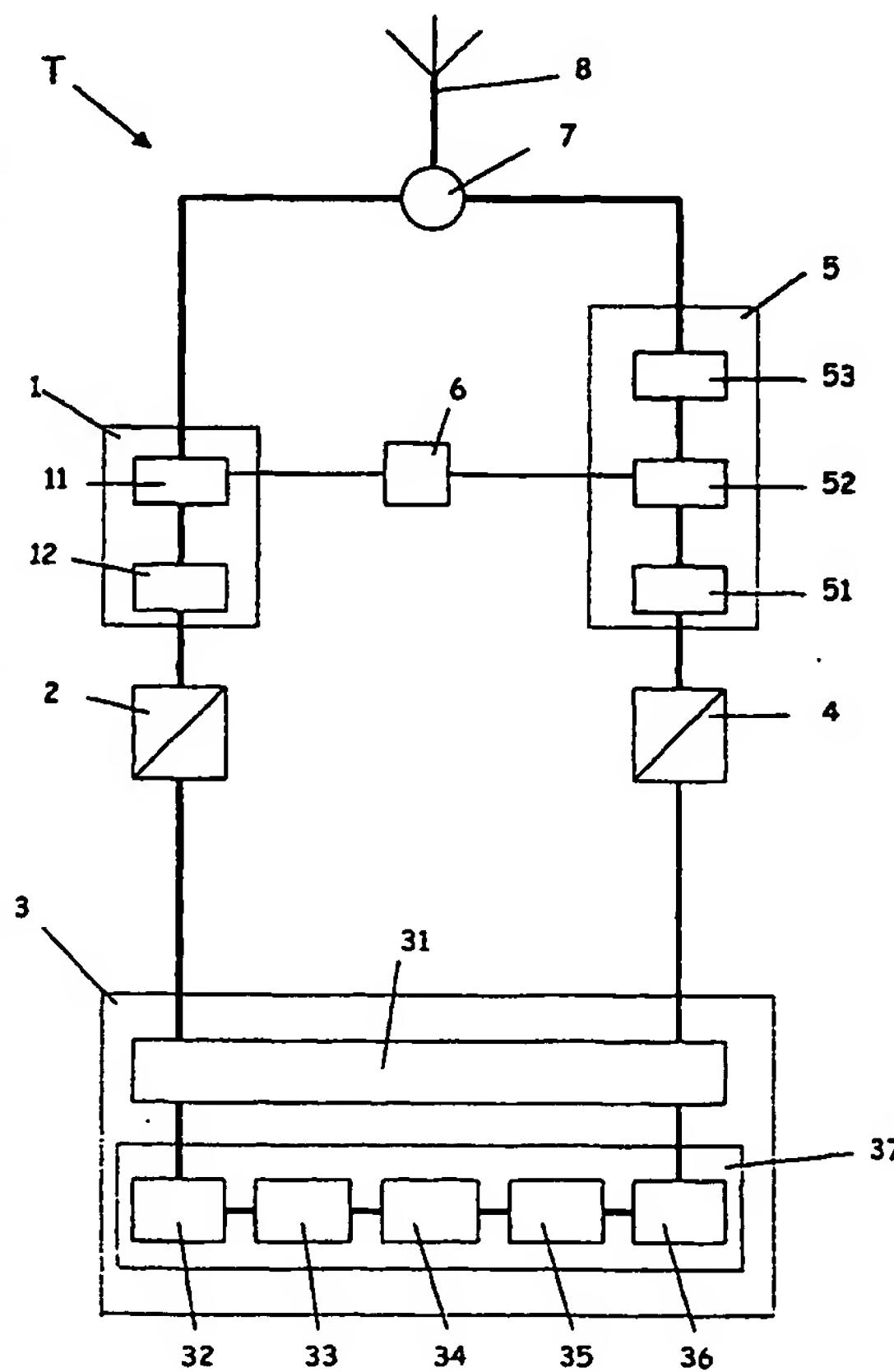
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(54) Title: A TRANSPONDER DEVICE



(57) Abstract: The invention refers to a transponder device including a receiver unit (1), a processing unit (3) and a transmitter unit (5). The receiver unit is arranged to receive a radar pulse including an interrogation signal. The processing unit includes first means (32, 33) arranged to interpret the interrogation signal, second means (34) arranged to determine if a response is to be transmitted and to generate a response depending on said determination, and third means (35, 36) arranged to generate a response signal from said response. The transmitter unit includes a mixer (52) for generating a response radar pulse and a frequency manipulator (53) for shifting the frequency of the generated response radar pulse. The transmitter unit (5) is arranged to transmit the frequency shifted response radar pulse.

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## 5 A transponder device

### THE BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention refers to a transponder device, which  
10 is arranged to receive a radar pulse and to transmit a response radar pulse depending on the received radar pulse.

It is known to utilise such transponder devices for identifying a friendly aircraft, friendly trucks and similar  
15 own craft or vehicles. Thereby the so called IFF-technique (Identification Friend or Foe) is utilised for identifying a friendly aircraft when it is seen observed by a radar. An encoded interrogation signal activates a transponder device, which is provided on the friendly aircraft and which thereby  
20 initiates an automatic transfer of a correctly encoded identification signal. The interrogation signal may, for instance, be transferred at 1,03 GHz and the identification signal at 1,09 GHz. Such transponder devices are thus arranged to receive the interrogation signal at a fixed  
25 frequency and to transmit the identification or response signal at another fixed frequency. Furthermore, transponder devices are usually separated from the radar with which they co-operate, i.e. the transponder device receives and transmits at other frequencies than the frequencies at which  
30 the radar operates. Corresponding technique is used by civil air traffic control for identifying principally all aircraft within a controlled air space. The civilian radar, a so called "Secondary Surveillance Radar", SSR, identifies aircraft individual and its height.

One problem with the devices of today is the difficulties to be able to separate friend and foe. In military systems, there are two main requirements. The transponder device must not be activatable by the opponent to give away the presence 5 of own aircraft or vehicles, nor to support radar line up of a foe. When the transponder responds to an allowed response, the risk should be very low that the opponent gives a response as if it would have been one of the own aircraft.

#### 10 SUMMARY OF THE INVENTION

The object of the present invention is to provide a transponder device, which is intended for a radar and by which objects could be identified as belonging to the own 15 vehicles, aircraft or boats. Furthermore, it is aimed at a device fulfilling the two requirements mentioned above. These requirements are to be fulfilled even if a foe get hold of construction basic data or equipment.

20 This object is obtained by a transponder device, including a receiver unit, which is arranged to receive a radar pulse including an interrogation signal, a processing unit, which includes first means arranged to interpret the interrogation signal, second means arranged 25 to determine if a response is to be transmitted and to generate a response depending on said determination, and third means arranged to generate a response signal from said response, and a transmitter unit, which includes a mixer for 30 generating a response radar pulse and a frequency manipulator for shifting the frequency of the generated response radar pulse, wherein the transmitter unit is arranged to transmit the frequency shifted response radar pulse, wherein the processing unit includes a memory member, 35 which is arranged to store the interrogation signal and which includes a volatile memory.

By such a transponder device, it is possible to identify an interrogation signal, which may be hidden in and included by the radar pulse, and in particular, in one single radar pulse. No further transmitter, which operates at another frequency than the radar and is possible to observe for foe, needs to be used. Consequently, the present invention defines a technique, which makes it possible to extract a correct allowed interrogation pulse and therefrom generate a correct response pulse. Thanks to the proposed volatile memory, the interrogation signal may be processed by digital technique and a response, which depends on the interrogation signal, may be produced or calculated.

15 Thanks to the shifting of the frequency of the response radar pulse, the response radar pulse may be identified and separated from target echoes and ground returns, so called ground clutter. The frequency of the response radar pulse is suitably shifted so much that the response radar pulse may 20 be discerned and identified by means of a so called Doppler radar.

According to an embodiment of the invention, said second means are arranged to generate said response depending on if 25 the interrogation signal includes information fulfilling a certain condition. In such a way, the interrogation signal can only be responded to by a transponder device, which may find, identify and interpret the interrogation signal and which knows which response is to be produced for the 30 interrogation signal in question. The response may include information about the identity of the one carrying the transponder device.

According to a further embodiment of the invention, the 35 memory member includes a so called DRFM-unit, i.e. a digital radio frequency memory. By such a DRFM-unit, the radar pulse

may include several bits, which define the identity of the interrogator as well as give a basis for the encrypting of the response.

5 According to a further embodiment of he invention, said first means include a demodulating member, which is connected to the memory member and arranged to read a code in the form of a first bit pattern from the interrogation signal. Furthermore, said first means may include a  
10 decrypting member for decrypting the first bit pattern. In such a way the security can be further improved. Advantageously, said second means may thereby be arranged to determine if a response is to be given and to generate this response in the form of a second bit pattern from the  
15 information included in the first bit pattern. Such a digital processing of the bit patterns may be obtained in a simple and efficient manner by means of said DRFM-unit. Furthermore, said third means may include a modulating member, which is arranged to generate said response by  
20 modulating the second bit pattern. Said third means may also include an encrypting member, which is arranged to encrypt the second bit pattern before it is transferred to the modulating member in order to make it more difficult for an unauthorised individual to obtain a correct response to the  
25 interrogation signal.

According to a further embodiment of the invention, the transponder device includes an analog-digital converter unit, which is provided between the receiver unit and the  
30 processing unit and is arranged to convert the received, analog interrogation signal to a digital interrogation signal, and a digital-analog converter unit, which is provided between the processing unit and the transmitter unit and is arranged to convert the generated, digital response signal to an analog response signal.

According to a further embodiment of the invention, the transmitter unit includes a filter, which is provided between the digital-analog converter and the mixer, and is arranged to filtrate over-frequencies. Furthermore, the  
5 receiver unit may include a mixer and a filter arranged to filtrate over-frequencies. An oscillator, which is connected to the mixer of the receiver unit and to the mixer of the transmitter unit, and is arranged to provide a frequency adapted to the radar unit with which the transponder device  
10 should co-operate.

According to a further embodiment of the invention, an antenna member is connected to the receiver unit and the transmitter unit via a distribution member, which may  
15 include a circulator.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now to be explained more closely by  
20 means of an embodiment described by way of example and with reference to the drawings attached, in which

Fig 1 discloses a schematic block diagram of a transponder device according to the invention, and  
Fig 2 discloses the transponder device in Fig 1 in  
25 co-operation with a radar facility.

#### DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

Fig 2 discloses schematically a radar unit R, which is  
30 arranged to co-operate with a transponder device T according to the present invention. The transponder device T may be mounted to a vehicle in the form of a car, a tank, or any other ground-based vehicle. The transponder device T may also be mounted to an aircraft or a ship.

Fig 1 discloses schematically the design of the transponder device T. The transponder device includes a receiver unit 1, which is arranged to receive a radar pulse from a radar unit R, for instance as disclosed in Fig 2. The radar pulse includes an analog interrogation signal. Moreover, the transponder device T includes an analog-digital converter unit 2, which is arranged to convert the analog interrogation signal received by the receiver unit 1 to a digital interrogation signal. The digital interrogation signal is processed in a processing unit 3 of the transponder device T for generating a digital response signal. The digital response signal is converted in a digital-analog converter unit 4 of the transponder device T to an analog response signal. The response signal is processed and transmitted by a transmitter unit 5 back to the radar unit R. The transponder device T also includes an oscillator 6, a distribution member 7, in the form of a circulator, and an antenna member 8, which is arranged to receive the radar pulse from the radar unit R and to transmit a radar pulse to the radar unit R. It is to be noted that the receiver unit 1 and the response unit 5 of course may include a respective separate antenna, wherein it can be dispensed with the distribution member 7.

The receiver unit 1 includes a mixer 11 and a filter 13. By means of the mixer 11, the frequency of the received radar pulse may in a conventional manner be decreased to a manageable level, and by means of the filter, the radar pulse may be filtered in such a way that an identifiable interrogation signal is obtained. This analog interrogation signal is supplied to the analog-digital converter 2 and converted to a digital interrogation signal.

The processing unit 3 includes a memory member 31, a demodulating member 32, a decrypting member 33, a determining member 34, an encrypting member 35 and a

modulating member 36. The memory member 31 is, in the embodiment disclosed, a volatile memory, and in particular a so called digital radio frequency memory (DRFM). The digital radio frequency memory 31 enables an analysis of a radar 5 pulse and, therefore, has to operate at a very high frequency, i.e. the memory 31 should be able to receive and analyse the radar pulse within a time period in the order of  $10^{-7}$  to  $10^{-10}$  s. The demodulating member 32, the decrypting member 33, the determining member 34, the encrypting member 10 35 and the modulating member 36 may be realised by a fast processor 37, a so called CPU, Central Processing Unit. The demodulating member 32 and the modulating member 36 are directly connected to the memory member 31 for co-operation and exchange of data with the memory member 31.

15 The digital interrogation signal, which is a digital representation of the interrogation signal, is stored and kept available in the memory member 31. From the memory member 31, the signal is loaded to the demodulating member 20 32, which is arranged to read a code in the form of a first bit pattern from the interrogation signal. This code is in the embodiment disclosed encrypted, and the first bit pattern is supplied to the decrypting member 33 for decrypting thereof. The decrypting member 33 is connected to 25 the demodulating member 32 and the determining member 34, which is supplied with the decrypted bit pattern in the form of an interrogation. With the aid of the information contained in this interrogation, it is determined if the radar pulse received is to be responded to or not. If the 30 determining member 33 determines that the interrogation is to be responded to, a response is prepared from the information included in the interrogation and the information about the one carrying the transponder device T. The response so prepared, which exists in the form of a second bit pattern, is supplied to the encrypting member 35. The second bit pattern is encrypted and thereafter supplied 35

to the modulating member 36 for modulating the second bit pattern for the generation of a digital modulated response signal. This signal is supplied to and kept available in the memory member 31 for delivering of a response signal with a  
5 very short time delay.

From the memory member 31, the digital modulated response signal may be supplied to the digital-analog converter 4, which is arranged to convert the generated, digital response  
10 signal to an analog response signal.

The analog response signal is transferred to the transmitter unit 5, which includes a filter 51 arranged to filtrate over-frequencies, a mixer 52 and a frequency manipulator 53.  
15 By means of the mixer 52, the response signal is mixed in a radar pulse signal with a suitable frequency. By means of the frequency manipulator 53, the frequency of the radar pulse signal is shifted so much that the it can be received by a Doppler radar and that the response signal can be  
20 separated from target echoes and ground clutter.

The oscillator 6 is connected to the mixer 11 of the receiver unit 1 and to the mixer 52 of the transmitter unit 5. The oscillator 6 is arranged to adjust the transponder device to the correct frequency range by providing a frequency, which is adapted to the radar unit R with which the transponder device T is to co-operate, i.e. within a frequency range from 2-18 GHz. This means that the frequency of the oscillator 6 is to have a predetermined difference to  
30 the frequency of the radar unit R.

The invention is not limited to the embodiment disclosed but may be varied and modified within the scope of the following claims.

The transponder device T according to the invention may be used, not only for identifying vehicles and other objects, but also as ground beacon, where a response including the identity of the ground beacon and possible additional 5 information may be obtained.

Claims

1. A transponder device including  
a receiver unit (1), which is arranged to receive a  
5 radar pulse including an interrogation signal,  
a processing unit (3), which includes first means (32, .  
33) arranged to interpret the interrogation signal, second  
means (34) arranged to determine if a response is to be  
transmitted and to generate a response depending on said  
10 determination, and third means (35, 36) arranged to generate  
a response signal from said response, and  
a transmitter unit (5), which includes a mixer (52) for  
generating a response radar pulse and a frequency  
manipulator (53) for shifting the frequency of the generated  
15 response radar pulse, wherein the transmitter unit (5) is  
arranged to transmit the frequency shifted response radar  
pulse, wherein the processing unit (3) includes a memory  
member (31), which is arranged to store the interrogation  
signal and which includes a volatile memory.  
20
2. A transponder device according to claim 1, wherein said  
second means (34) are arranged to generate said response  
depending on if the interrogation signal includes  
information fulfilling a certain condition.  
25
3. A transponder device according to any one of claims 1  
and 2, wherein the memory member (31) includes a so called  
DRFM-unit, i.e. a digital radio frequency memory.
- 30 4. A transponder device according to any one of claims 1 -  
3, wherein said first means (32, 33) include a demodulating  
member (32), which is connected to the memory member (31)  
and arranged to read a code in the form of a first bit  
pattern from the interrogation signal.  
35

5. A transponder device according to claim 4, wherein said first means (32, 33) include a decrypting member (33) for decrypting the first bit pattern.

5 6. A transponder device according to any one of claims 4 and 5, wherein said second means (34) are arranged to determine if a response is to be given and to generate this response in the form of a second bit pattern from the information included in the first bit pattern.

10

7. A transponder device according to claim 6, wherein said third means (35, 36) includes a modulating member (36), which is arranged to generate said response by modulating the second bit pattern.

15

8. A transponder device according to claim 7, wherein said third means (35, 36) includes an encrypting member (35), which is arranged to encrypt the second bit pattern before it is transferred to the modulating member (36).

20

9. A transponder device according to any one of the preceding claims, including an analog-digital converter unit (2), which is provided between the receiver unit (1) and the processing unit (3) and is arranged to convert the received, 25 analog interrogation signal to a digital interrogation signal.

10. A transponder device according to any one of the preceding claims, including a digital-analog converter unit (4), which is provided between the processing unit (3) and the transmitter unit (5) and is arranged to convert the generated, digital response signal to an analog response signal.

35 11. A transponder device according to claim 10, wherein the transmitter unit (5) includes a filter (51), which is

provided between the digital-analog converter (4) and the mixer (52), and is arranged to filtrate over-frequencies.

12. A transponder device according to any one of the  
5 preceding claims, wherein the receiver unit (1) includes a  
mixer (11) and a filter (12) arranged to filtrate over-  
frequencies.

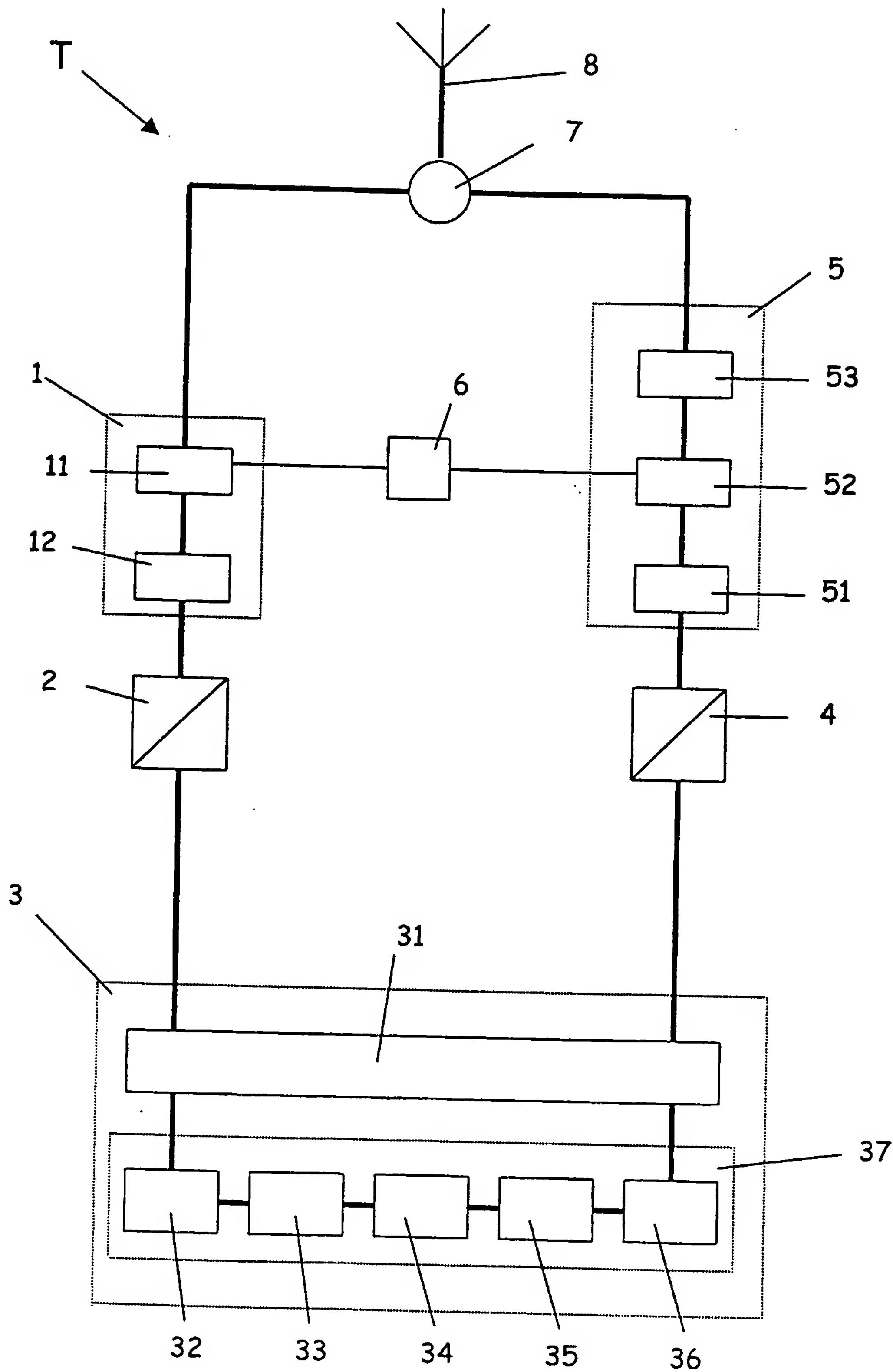
13. A transponder device according to claim 12, including  
10 an oscillator (6), which is connected to the mixer (11) of  
the receiver unit (1) and to the mixer (52) of the  
transmitter unit (5), and is arranged to provide an adapted  
frequency by which the frequency of the receiver unit (1)  
and the transmitter unit (5) is adapted to a co-operating  
15 radar unit (R).

14. A transponder device according to any one of the  
preceding claims, including an antenna member (8), which is  
connected to the receiver unit (1) and the transmitter unit  
20 (5) via a distribution member (7).

15. A transponder device according to claim 14, wherein the  
distribution member (7) includes a circulator.

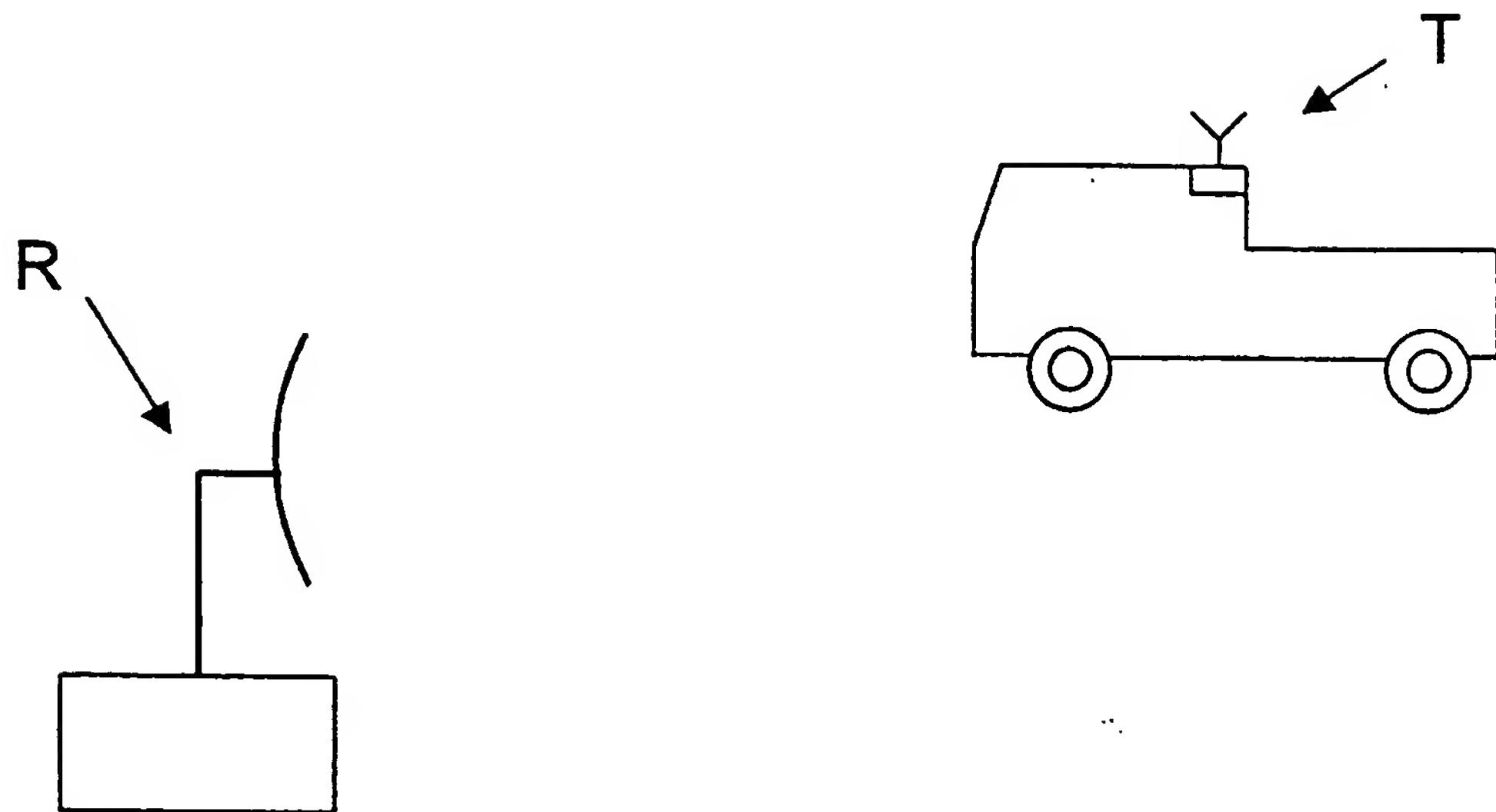
Fig 1

1/2



2/2

Fig 2



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/00437

## A. CLASSIFICATION OF SUBJECT MATTER

**IPC7: G01S 13/78**

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**IPC7: G01S**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**SE,DK,FI,NO classes as above**

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 9961937 A1 (NORTHROP GRUMMAN CORPORATION), 2 December 1999 (02.12.99), page 1, line 19 - line 22; page 3, line 28 - page 5, line 23, figures 1,2, abstract  --	1-15
A	US 5712628 A (W.PHILLIPS ET AL), 27 January 1998 (27.01.98), column 5, line 34 - column 6, line 17, abstract  --	1-15
A	US 5508705 A (N.SPIESS), 16 April 1996 (16.04.96), figure 1, abstract  --	1-15

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents	"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 01/00437

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

30/04/01

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